R-341 - Rpt #4(Final)
Contract: DA19-129-qm-1990
Truesdail Laboratories, Inc.

Optimal Water Storage Study of Multifunctional Water-Commode Containers

Period: 30 April 1962 - 29 April 1963

ARMED FORCES FOOD AND CONTAINER INSTITUTE
U. S. Army Quartermaster Research and Engineering Center
Chicago 9, Illinois

AD ______________________ Accession No. __________

Truesdail Laboratories, Inc., Los Anfeles, Calif.
OPTIMAL WATER STORAGE STUDY OF MULTIFUNCTIONAL WATER-COMMODE CONTAINERS.

B.S.Ward, I.Bandziulis, C.L.Blohm and P.J.Charley
Final Report, Phase A; Phase B - Part I;
Phase C - Part II; 29 May 1963. 15 pp.
(Contract DA19-129-QM-1990 (O.I.6076)). Project #2210.8
Unclassified Report

Data are presented on potability of a single source tap water stored in fiber drums lined with polyethylene, laminated polyethylene-cellophane and polyvinyl films, and on comparative storability in these liner materials of tap waters from 10 different geographical areas. Total storage period for both cases was 300 days with intra-period inspections. Storage conditions were 45 to 95°F, 20 to 90% relative humidity, indoors and dry. While all waters were considered potable under emergency conditions, by taste panel tests and chemical and bacteriological analyses, those stored in the laminated and vinyl films had a disagreeable taste. Only 4 mil polyethylene is considered an acceptable liner for this extended period. No significant differences were found in the comparison tests of the 10 different source waters, with the exception of those from Chicago and Houston. Fiber drums and 4 mil polyethylene liners are considered satisfactory for storage of potable tap water under the conditions used. Storage cost data are presented. Improved drums and liners for more rigorous storage conditions should be investigated.

1. Water Storage Study
2. Contract DA19-129-QM-1990 (O.I. 6076).

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CONTRACT RESEARCH PROJECT REPORT

ARMED FORCES FOOD AND CONTAINER INSTITUTE, CHICAGO
U. S. Army Quartermaster Research and Engineering Center,
Natick, Massachusetts

Truesdail Laboratories, Inc.
4101 No. Figueroa Street
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Official Investigators:
I. Bandziulis
C. L. Blohm

Project Nr. 2210.8
Contract: DA19-129-qm-1990
Report Nr.: 4(Final)
File Nr.: R-341
Period: 30 April 1962 -
29 April 1963
Initiation Date: 30 April 1962

Title of Contract: Optimal Water Storage Study of Multifunctional Water-Commode Containers

FINAL REPORT

PHASE A; PHASE B - PART I. WATER STORAGE

PHASE C - PART II. WATER COMPATIBILITY

OPTIMAL WATER STORAGE STUDY OF MULTIFUNCTIONAL WATER-COMMODE CONTAINERS

CONTRACT No. DA19-129-QM-1990 (O.I.6076)

PROJECT No. 2110.8

QUARTERMASTER FOOD AND CONTAINER INSTITUTE

PREPARED BY: C. BRADLEY WARD, JR.
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TRUESDAIL LABORATORIES, INC.

4101 N. FIGUEROA STREET

LOS ANGELES 65, CALIF.

29 MAY 1963

TRUESDAIL LABORATORIES, INC.

FINAL REPORT

PHASE A; PHASE B - PART I. WATER STORAGE

Project Number 2210.8
Contract Number DA19-129-QM-1990 (O.I. 6076).

29 May 1963

I N T R O D U C T I O N

This report is submitted in accordance with the requirements stipulated in Article 1, Phase A, and Phase B - Part I of Contract DA19-129-QM-1990 (O.I. 6076) entered into between the Quartermaster Food and Container Institute and Truesdail Laboratories, Inc. on 30 April 1962. Data are presented on (a) Stackability to a height of 6 feet of plastic lined fiber drums filled with tap water for a period of 300 days, (b) Potability of stored tap water after a period of 300 days, (c) Review and summary of information presented in previous progress reports including results of the freezing-thawing cycle studies; (d) Comparative cost analyses.

M A T E R I A L S

Drums. The drums employed for water storage were essentially in conformance to specification MIL-D-43055 (QMC), 15 Jan. 1962, Classes A, B, C & D. However dimensions were changed to conform to suggestions made in our original proposal, viz., a total filled capacity of about ten gallons. All drums had nominal dimensions of 13 1/4" dia. x 16" ht. Class A drums were obtained from the Continental Can Company, of Los Angeles, California, and Class B, C & D drums were obtained from the Rheem Manufacturing Company, of Southgate, California.

Liners. Three liner materials were used: 4 mil polyethylene (Dow Chemical Co.); 2 mil polyethylene - 0.9 ml. cellophane laminate (Dobeckmun Division of Dow); 3 mil polyvinyl (VBA 9020 - Union Carbide).

All liners were fabricated essentially in conformance to specification MIL-D-43056 (QMC), 15 Jan 62, but dimensions were altered to fit drums of sizes used. All liners were approximately 24" x 34" flat and were supplied by the Richmond Corporation, Highland, California.

Samples of the three liner materials are provided the Project Officer with submittal of this report.

Water. Los Angeles tap water.

T E S T I N G P R O C E D U R E

Twelve of each of the four classes of drums were fitted respectively with one of the three types of plastic liners (total 48 drums). They were then filled with water and the liners were closed by tying with twisted wire bag ties. For each type of liner, one set each of the four classes of drums was stacked four-high, (approximately six feet), making a total of 48 drums in the stacking tests. The drums were stored in a large room at ambient conditions. Results on potability of stored water for storage periods of 97 and 210 days have been previously reported. This report presents final observations after the specified total storage period of 300 days, from 15 June 1962 to 11 April 1963. Over the total storage period temperature ranged from 45 to 95°F

and relative humidity ranged from 20 to 90%. The 12 o'clock noon average relative humidity ranged from 43 to 63%. In the first 70 days of the storage period, temperature and humidity data were taken from local weather bureau reports. Later, a recording hygrothermograph was installed and, for the remaining period, continuous recordings were made. The chart recordings for the final 90 day period are reproduced on pages 3 to 7, incl. Monthly data from the charts and from corresponding weather reports covering the total storage period are listed in Table I.

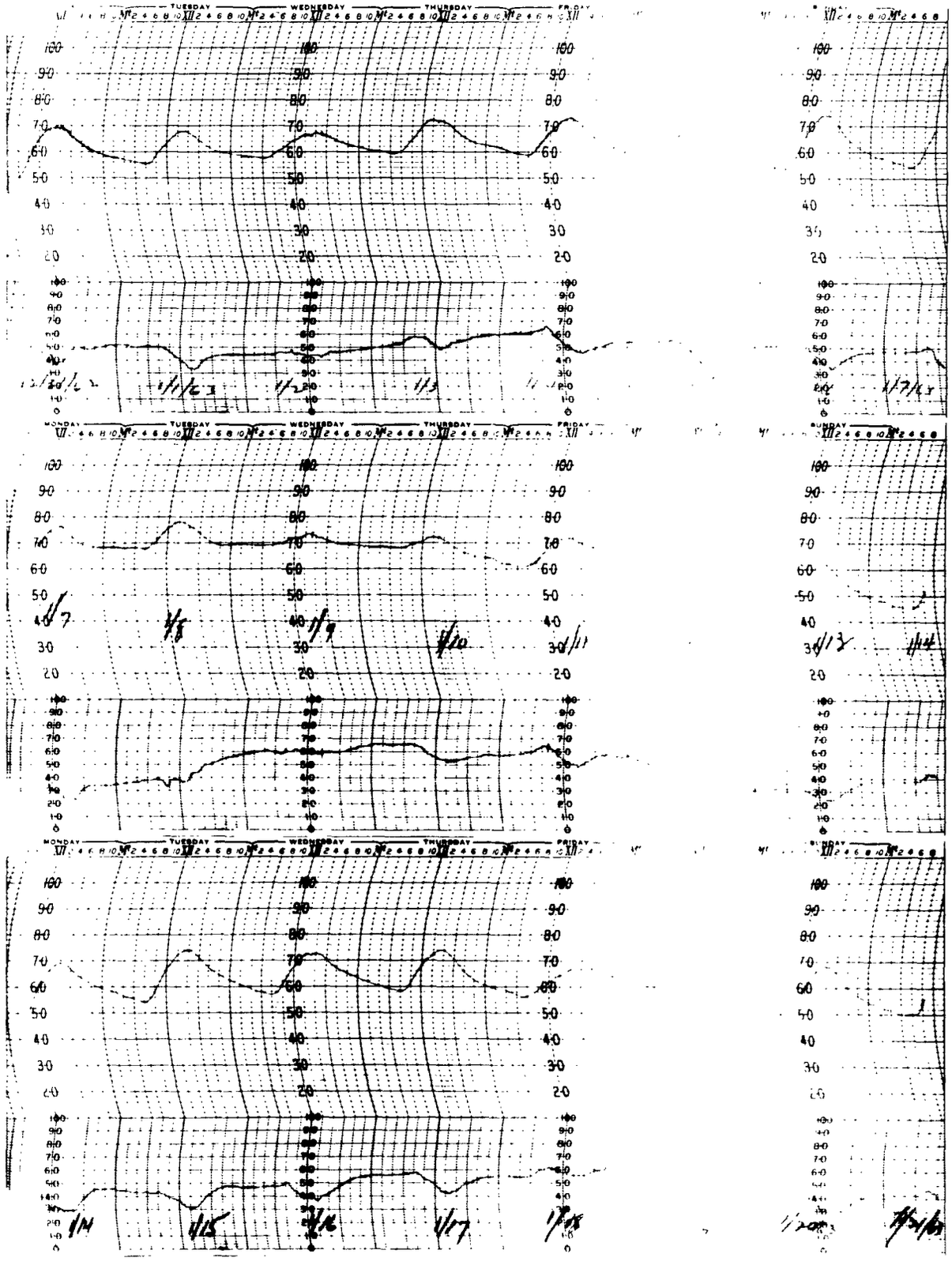
TABLE I

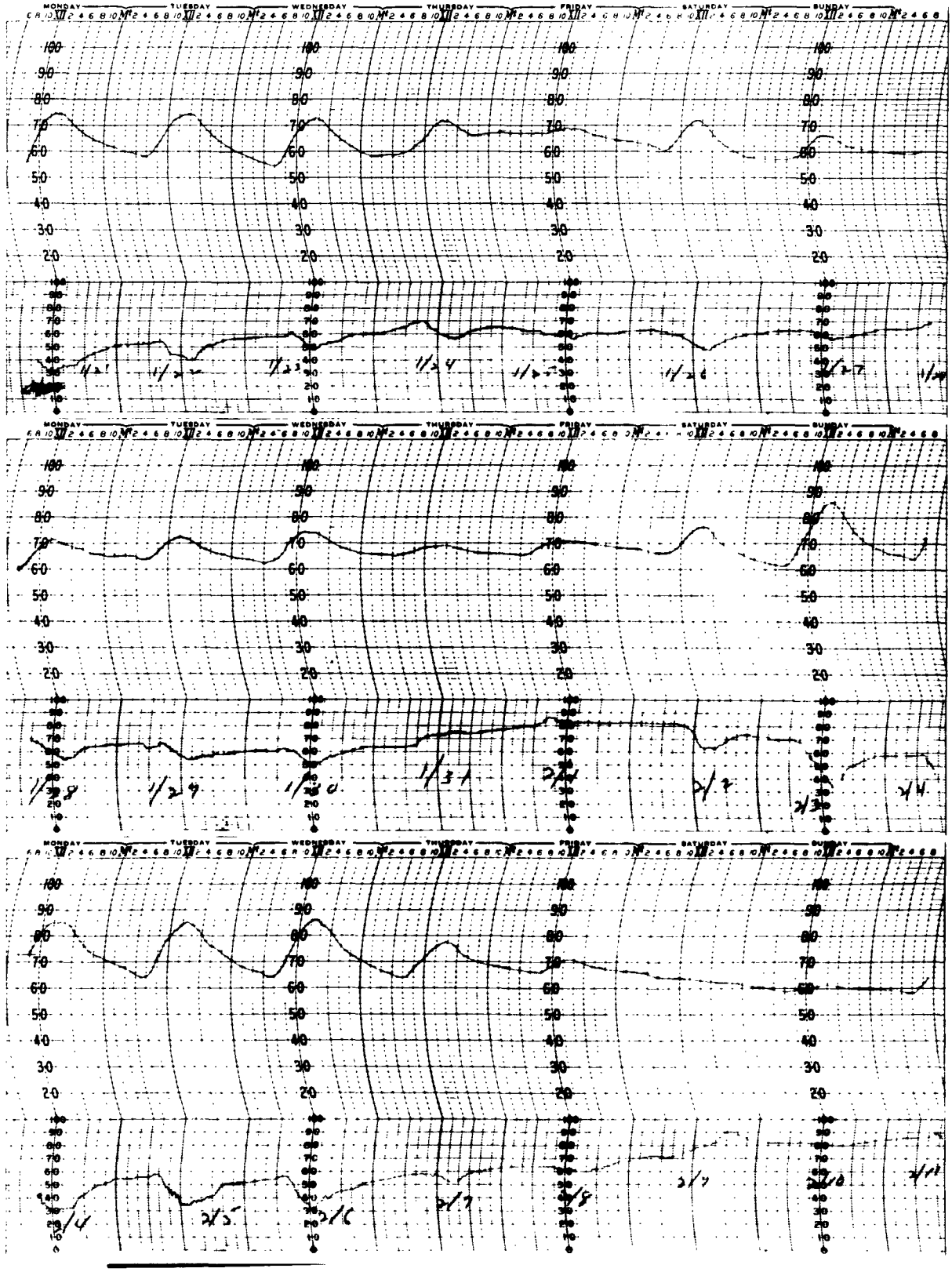
TEMPERATURE AND HUMIDITY DATA FOR DRUM STORAGE. 15 JUNE '62 to 11 APRIL '63.-- 300 DAYS

	TEMPERATURE °F						RELATIVE HUMIDITY %					
	FROM CHARTS			WEATHER BUREAU			FROM CHARTS			WEATHER BUREAU		
	MAX.	MIN.	AV.	MAX.	MIN.	AV.	MAX.	MIN.	12 Noon AV.	MAX.	MIN.	12 Noon AV.
June 15-30	Not Recorded			91	55	68.2	Not Recorded			92	29	50
July 1-31	"			86	57	70.1	"			98	32	51
Aug. 1-24	"			94	59	70.1	"			95	26	43
Aug. 25-31	95	74	83.0	90	61	73.7	64	40	52	99	38	49
Sept. 1-30	95	66	78.6	94	57	70.9	72	33	55	98	21	48
Oct. 1-31	86	59	72.3	93	52	65.7	80	21	63	100*	12	51
Nov. 1-30	84	53	67.0	81	46	60.6	77	24	55	100*	12	50
Dec. 1-31	79	48	64.5	78	41	57.4	84	28	54	100*	8	45
Jan. 1-31	78	45	64.8	77	34	55.6	77	23	47	96	7	41
Feb. 1-28	86	58	69.7	88	49	62.7	90	23	55	98	6	52
Mar. 1-31	84	50	67.1	79	42	58.3	78	20	47	97	5	41
Apr. 1-14	86	54	69.9	79	45	60.6	76	30	46	97	18	43

* FOG - Total precipitation through 31 Dec. 0.14 in.

It will be observed that temperatures and relative humidities taken at the point of storage moved over narrower ranges than Weather Bureau reports for the same periods.


TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SUNDAY
MONDAY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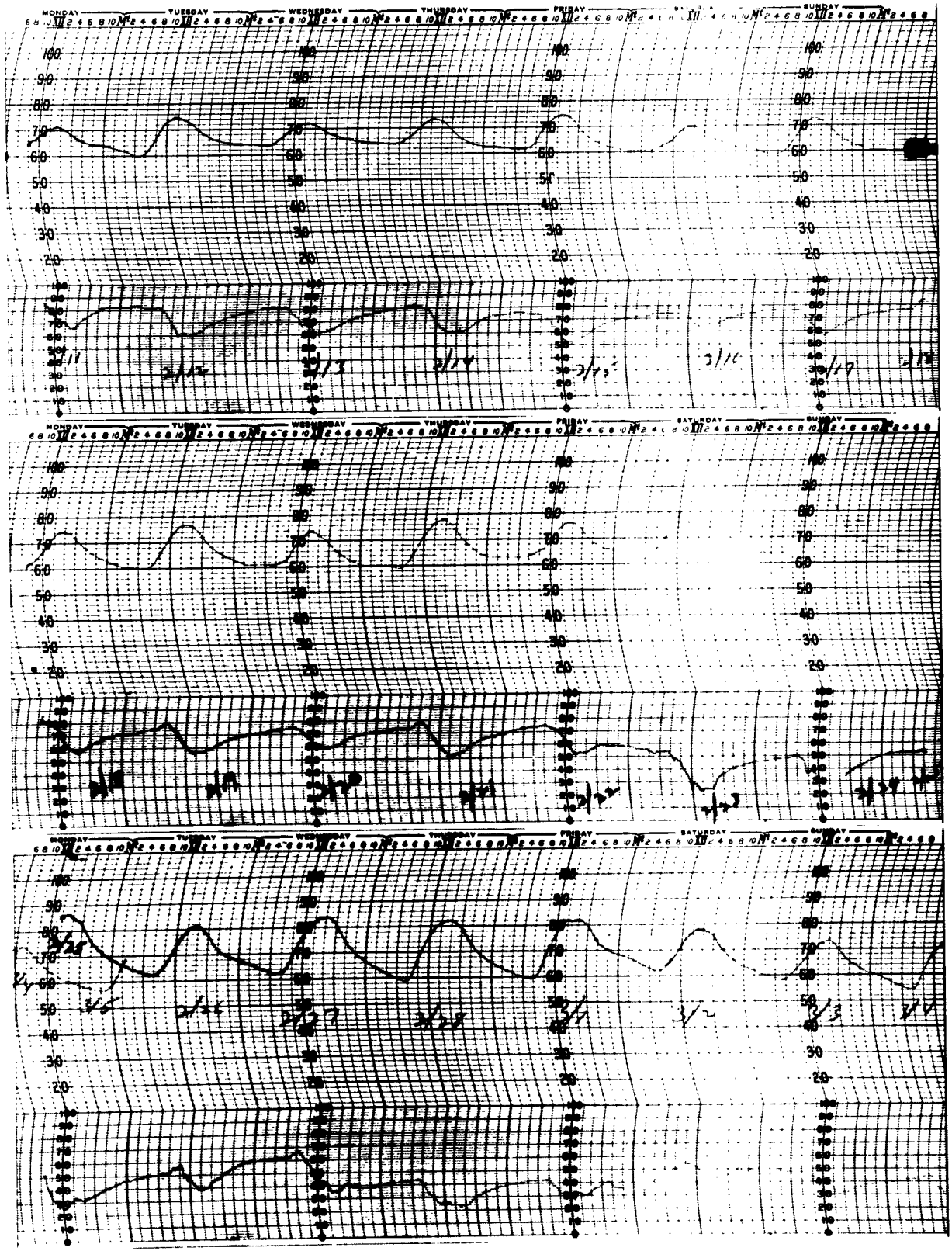
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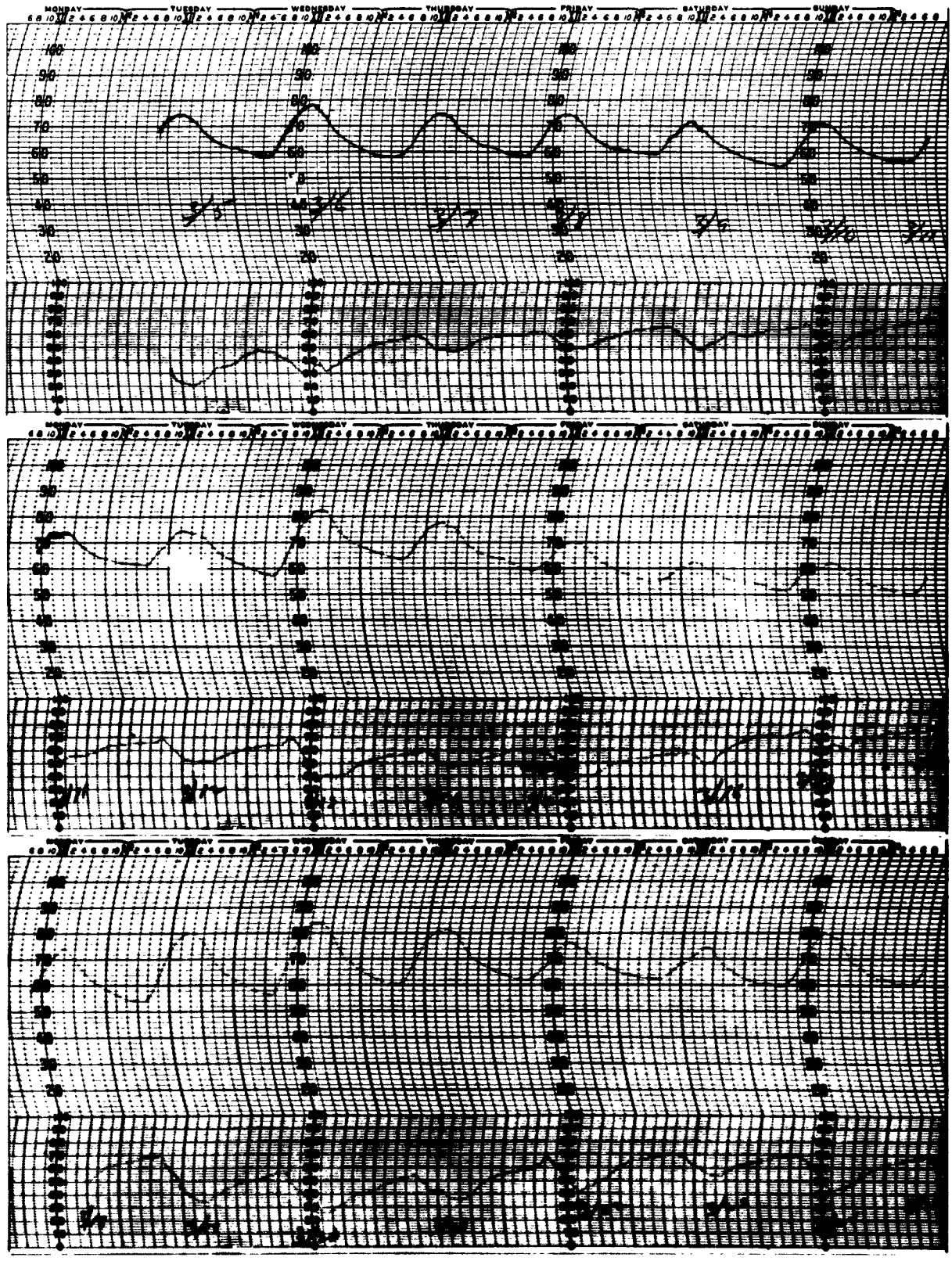
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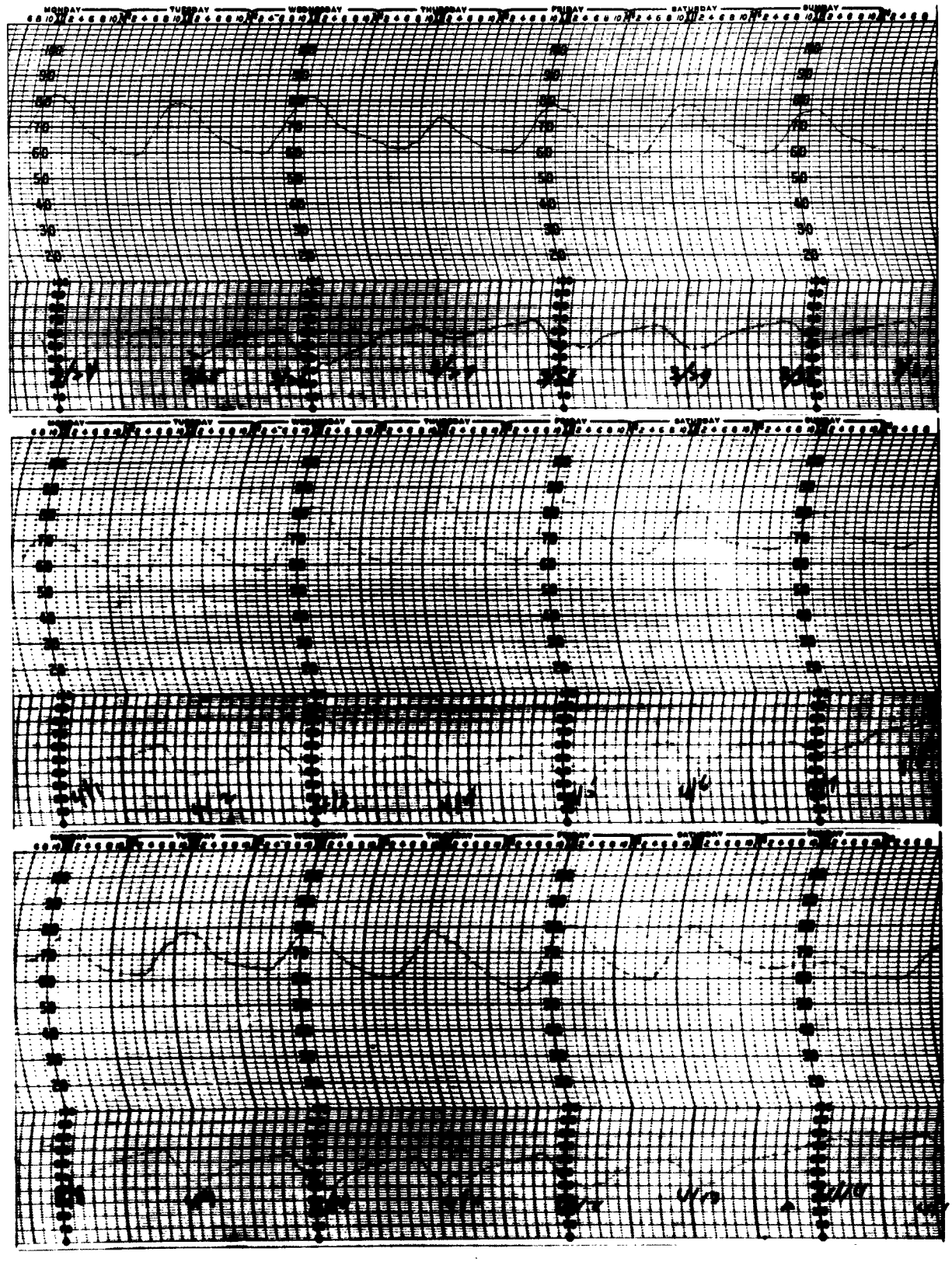

At the conclusion of the storage period the drums were opened and the water was sampled. Taste and odor tests were made by a five-man panel. In addition, samples were analyzed for dissolved oxygen, COD, pH and bacteriological plate counts were made. Finally, the condition of both drums and liners was observed and recorded.

RESULTS AND DISCUSSION

STACKABILITY OF FILLED DRUMS. In accordance with work scope specifications, each class of drum fitted with one of the three types of liners and filled with Los Angeles tap water was stacked four-high (approximately 6 feet) in order to fulfill the requirements of the 300-day stackability tests. This portion of the program utilized a total of 48 drums. At the same time an additional 48 drums were filled for storage to satisfy the 90-day and 180-day potability tests. Initially, several of the drums were lost due to liner failures. However, a sufficient number of drums were retained to finish out the required evaluations.

Both the vinyl liners and the laminated polyethylene-cellophane liners were subject to failure at the seams. The polyethylene liners exhibited good initial integrity with the exception of two which had pinholes. It was not determined as to whether these pinholes were present in the original tubing from which the liners were fabricated or whether they were produced by physical injury during the placing of the liners in the drums. All of the failures developed in the first few hours or, at the most, two days after the drums were filled. Of course, where failures occurred the drums were lost since the physical integrity of the fiber drums, regardless of the differences between classes, was completely destroyed upon saturation with water.

On the other hand, those drums which did not exhibit initial failure withstood the 300-day stacking test with no difficulty. There was no apparent difference in the durability of the four classes of drums under the storage conditions.

It can be concluded from the test results that plastic lined fiber drums are suitable for long term storage of water if the following conditions are met:

1. The liners must be intact and drums should be observed after filling for at least 48 hours before being put into storage. Any failures occurring in this period, of course, would be discarded.

2. Storage conditions must be dry and temperature must be above 32°F to prevent condensation.

3. A condition which was not investigated but which probably needs to obtain is that the storage area be free of rodents or insects which might attack the fiber drums.

FREEZING-THAWING TESTS. The studies conducted under the specific conditions for the freezing-thawing tests have been reported and discussed in detail in Progress Report No. 1 of 10 August 1962.

Without reiterating the discussion, a brief recapitulation of the conclusions and recommendations states that ".....ordinary fiber drums lined with the three types of plastic films used in this experiment are not suitable for storage of water under conditions of alternate freezing and thawing. The plastic liners showed very poor integrity.....ordinary fiber drums are not suitable under conditions resulting in condensation of moisture from the atmosphere."

STORED WATER POTABILITY. The results of the potability examinations from the drum storage tests at the end of 90 and 210 days have been reported in Progress Reports Nos. 2 and 3 of 21 November 1962 and 25 February 1963, respectively. Summarized in Tables II and III following are the physical and bacteriological data on the final tests and compared with those results from the shorter storage periods.

Taste and Odor. As was done in earlier tests, taste and odor examinations were performed by a five-man panel using a high quality local bottled water as a standard. Samples and the standard were coded so that the tasters could not identify them. The results obtained were subjective and qualitative only. In contrast to the observations from the 90 and 210 day tests, there was little observable difference between the water stored in the three types of liners although those from the polyethylene liner showed a slight preference. No influence on the results could be attributed to the class of drum used. It was the general consensus of the taste panel that all waters would be acceptable and, therefore, "potable" under emergency conditions. Again, there was no question, however, as to the definite "chemical" flavor of these waters. As was found after the two shorter taste periods, all stored samples showed a light flocculent precipitate.

Chemical Analyses. Chemical data run on duplicates of each liner material for the final test period are presented below in Table II. For comparison, the results from the prior tests are included:

TABLE II

CHEMICAL ANALYSES

LINER	DISSOLVED O_2, ppm.			COD, ppm		pH	
	97 days	210 days	300 days	210 days	300 days	210 days	300 days
Polyethylene	7.09	9.35	9.00	5.1, 9.0	14.9	7.85	7.85
Polyethylene Cellophane	5.96	9.05	8.44	8.8	21.6	7.80	7.90
Polyvinyl	7.31	9.31	8.86	5.1	60.2	7.80	7.84
Control (fresh tap water)	7.93	7.93	7.93	0.0	0.0	8.10	8.10

The results indicate that the waters remained substantially aerobic. Slight differences in dissolved oxygen over the several test periods may be due to temperature effects and "breathing" through the liner material. The COD values found in contrast with the 0.0 value for the control indicate definite dissolution of chemical materials from the liners into the body of the stored water. Some of the increase in COD values may also be due to the accumulation of bacterial residues. It must be recognized, however, that COD analyses at these very low levels are not highly reliable, particularly in waters that have substantial chloride ion content. The slight variation in pH is not thought to be significant.

Bacterial Plate Counts. Presented in Table III are duplicate counts run on each liner material and, for comparison, similar counts from the two prior test periods:

TABLE III

BACTERIOLOGICAL PLATE COUNTS - Organisms/ml.

LINER	AFTER 97 DAYS[1]	AFTER 210 DAYS[1]	AFTER 300 DAYS[2]
Polyethylene	32,000	4,800; 14,000	5,700; 8,600
Polyethylene Cellophane	13,000	3,900; 4,100	2,800; 2,900
Polyvinyl	120,000	33,000; 66,000	20,000; 21,000
Control (original water)	130	130	130

[1] Standard plate counts - 24 hrs., 35°C
[2] Special plate counts - 48 hrs., 35°C

Coliforms were not re-run on the storage samples since the original count was negative, viz., less than 2 per 100-ml. It may be observed that plate counts have substantially diminished over the storage period. Since, as pointed out above, the waters remained adequately aerobic, this reduction in growth would seem to indicate the gradual loss of nourishment to the microbiological population of the system. One might expect over a further extended storage period that the viable organisms would drop to essentially zero

In light of the above, and since organisms found were in relatively low concentrations, it is felt that there need not be any concern for lack of potability of the water due to the presence of microbiological contamination.

C O S T S

Approximate cost information is listed below. For comparison, costs are presented on the 14" x 16" drums and their corresponding liners as used in the studies, together with costs on 15-3/4" x 22" drums and liners per specifications MIL-D-43055 and MIL-B-43056. Finally, data are presented on steel drums and on double 4 mil polyethylene liners per MIL-B-43068A. In order to compare costs on a volume basis, it is assumed the water fill volume for the 14" x 16" drums would be 12 gals. or 48 qts. For the MIL-spec. 15-3/4" x 22" drums, the fill volume would be 17 gals or 68 qts.

D R U M C O S T S

CLASS	SIZE, in.	PRICE/100	LOT SIZE	F.O.B. POINT
A	14 x 16	$ 88.80	1,568-cl	Pittsburgh, California
		81.60	1,568-cl	Carteret, N.J. or Vanwert, Ohio
	15-3/4 x 22	131.80	1,035-cl	Pittsburgh, California
		119.80	1,035-cl	Carteret, N.J. or Vanwert, Ohio
B	----------not available----------			
C	14 x 16	251.50	1,000	Los Angeles, California
		239.00	5,000	" " "
	15-1/2 x 22	268.58	1,000	" " "
		261.38	5,000	" " "
D	14 x 16	214.50	1,000	" " "
		203.80	5,000	" " "
	15-1/2 x 22	233.74	1,000	" " "
		224.08	5,000	" " "
Steel	17-1/2 gal., 26 gauge, 1 coat epoxy phenolic inside. Add $16.00 for printing.	285.00	1,000	Richmond, California
		260.00	5,000	" "

L I N E R C O S T S

MATERIAL	SIZE	PRICE/1,000	LOT SIZE	F.O.B. POINT
4 mil Polyethylene	24 x 34	$291.00	1,000	Highland,Calif.
		276.50	5,000	" "
Polyethylene-Cellophane (M-3200)		555.00	1,000	" "
		527.25	5,000	" "
Polyvinyl 3-mil 9020V		585.00	1,000	" "
		555.75	5,000	" "
4-mil Polyethylene	26-1/2 x 40	316.00	1,000	" "
		300.20	5,000	" "
4-mil Polyethylene Double Liners (MIL-B-43067-A)		570.00	1,000	" "
		541.50	5,000	" "

Examination of the foregoing data indicates that the least expensive combination of drums and liners for the two sizes is that of Class A drums fitted with single 4-mil polyethylene liners. For the smaller drums, holding 48 qts. of water, a cost of 2.28 cents per qt. is obtained, using the prices of $81.60/C for drums and $276.50/M for liners. For the larger drums, holding 68 qts. of water, a cost of 2.21 cents per qt. results, using the prices of $119.80/C for drums and $300.20/M for liners. Increased serviceability of the drums could be attained by going to the double 4-mil liners. Using this cost of $541.50/M in conjunction with the cost, again of $119.80/C for the larger Class A drums, a cost of 2.56 cents per qt. of water capacity is obtained.

The foregoing costs are not greatly in excess of the project objective cost of 1.5 cents per qt. However, the test results have shown the limited utility of fiber drums for water storage, and thus the cost figures are unrealistic except for limited locations where storage conditions are suitable.

For commode use, the drums with double liners may be suitable, since short term storage of wastes in a shelter would be expected to encounter normal living condition environment. The volumetric cost would be increased above the foregoing figures by about 20%, since the fill level for wastes is necessarily less than for stored water.

Finally, for comparison, recently supplied 17-1/2 gal., 26 gauge steel drums at $276.00/C (including printing) using single 4-mil polyethylene liners, result in a cost of 4.37 cents/qt., and with double 4-mil polyethylene liners, 4.72 cents/qt. While it is true that the steel drums have structural advantages, particularly in wet environments or where the liner might leak, it is seen that the cost above the minimum for the Class A fiber drums with double liners is increased by 84%.

In light of the foregoing, investigations directed toward water-proofing the fiber drums may be warranted to obtain a cost less than that for the steel drums, at least for use in some locations. In Southern California, for example, there is little likelihood of encountering freeze-thaw or condensation conditions in storage. Thus, even though the cost of the treated fiber drums were increased by 50%, i.e., from $119.80/C to $179.80/C and using double liners, the water storage cost would only be 3.09 cents/qt., a reduction from the steel drum cost of 4.72 cents/qt. or nearly 35%. Where millions of quarts of water storage capacity are involved, this cost reduction is very substantial in total dollars.

Very recently obtained information from publication of contract awards by the Defense Supply Agency indicates that contracts have been awarded for steel storage drums for as little as $154.00/C in quantities on the order of 100,000 units. While this price is substantially less than the small lot price presented above, by the same token the cost of fiber drums might well be reduced proportionately in large quantity purchases.

FINAL REPORT

PHASE C - PART II. WATER COMPATIBILITY

Project Number 2210.8
Contract Number DA19-129-QM-1990 (O.I. 6076).

29 May 1963

I N T R O D U C T I O N

This report is submitted in accordance with the requirements stipulated in Article 1, Phase C - Part II, of Contract DA19-129-QM-1990 (O.I. 6076) entered into between the Quartermaster Food and Container Institute and Truesdail Laboratories, Inc. on April 30, 1962. Data are presented on the storability of typical tap waters, obtained from ten metropolitan areas located throughout the continental United States. The waters were stored in small containers lined with three different types of plastic films, over a period of 300 days. The effect of the waters on the properties of the plastic films and the effect of the plastic films on the potability of the waters were studied.

M A T E R I A L S

Storage Containers: One-quart cylindrical ice cream cartons obtained locally.

Liners: 4 mil polyethylene (Dow Chemical Co.)
2 mil polyethylene - 0.9 mil cellophane laminate (Dobeckmun Division of Dow);
3 mil polyvinyl (VBA 9020 - Union Carbide).
All liner materials were made up in bags of approximately one-quart capacity.

Waters: As reported in Final Report, Phase C, Part I, 29 June 1962.

T E S T I N G P R O C E D U R E

An additional 30 bags of each of the three liner materials were opened after the 300-day storage period, following the same procedures as described in Final Report Phase C - Part I. The storage period extended from 25 May 1962 to 21 Mar. 1963. The containers were stored in a large room at ambient conditions, temperatures ranging from 45 to 95°F, and relative humidity from 20 to 90%.

R E S U L T S A N D D I S C U S S I O N

Weight Loss. Each of the containers was weighed and, again, as shown in the earlier reports, the polyethylene liners gave the best performance. None of them lost more than 10 gms. of water over the total 300-day period. Average loss was 8.3 grams, or between 1.2 and 2.1% loss over the range of initial fill weights recorded. The laminated polyethylene cellophane liners showed more weight loss. Of the 30 units tested, 22 showed weight loss of 31 gms. or less, average 24 gms, or between 3.3 and 5.4% of initial fill weights. The remaining 8 showed losses of 50 to 220 grams, all probably due to seam leaks since most of these liners failed at the seam under the burst tests. Of the polyvinyl liners 23 showed weight loss of 89 grams or less, average 53 gms. or between 5.9 and 8.5% of initial fill weights. Of the remaining 7, 3 failed during storage and the other 4 showed losses of from 117 to 140 gms.

Burst Tests. Burst tests were run as described in the earlier reports. The results from the 300-day storage period compared with those from the earlier storage periods are presented in Table I following:

TABLE I

AVERAGE BURST PRESSURE PSIG

LINER	INITIAL	AFTER 30 DAYS	AFTER 195 DAYS	AFTER 300 DAYS
Polyethylene	2.72	2.79	2.23	2.24
Polyethylene Cellophane	2.91	2.94	2.06	1.70
Polyvinyl	4.63	4.40	2.75	3.30

Examination of the tabulated data indicates that the major reduction in bursting strength occurred between the 30-day and 195-day storage periods with little further change between the latter period and the 300-day period. The reduction in bursting strength is not felt to be significant in affecting the liner integrity, at least for the polyethylene. For the other two liner materials, in most cases bursting occurred at the seams and there were some seam failures in storage. Whether or not the reduction in bursting strength involves the interaction of the stored water with the liner material or whether it is due largely to faulty seaming is not apparent.

No discernible differences could be observed in the average burst strengths of the liners containing waters from the 10 different sources at the end of the 300-day period. This finding is somewhat anomalous since at the end of the 195-day period a very definite effect had been observed on the liners containing the waters from Chicago, Ill. This one observation, however, may have been strictly fortuitous.

Taste and Odor. All waters were tasted by a five-man panel. Obviously, it is difficult to make precise comparison tastes over the elapsed period between the 30 day, 195 day, and 300 day tests. While there appeared to be some definite deterioration in taste quality between the first two tests, there was no observable further change between the 195 and 300 day tests. It may well be that the effect on taste of solutes from the liners reaches a "plateau" after about six months' storage. In some contradiction to the findings after 195 days, which showed the polyethylene liners to be superior to the other two materials, after 300 days little difference was found between the polyethylene and the laminated polyethylene-cellophane, but these were both superior to the polyvinyl liner material.

There did not appear to be as great differences between the tastes of waters from various sources after 300 days as had been noted after 195 days, with one exception. Again, the Chicago water, in all three liner materials, was definitely inferior to the waters from the other sources. Again, as was found in earlier tests, while all waters stored in the polyvinyl liners were considered objectionable by ordinary standards, the consensus of the panel was that these and the other waters would be acceptable, and, therefore, "potable," under emergency conditions.

Bacteriological Plate Counts. While plate counts were not run under this phase of the study after the 195 day storage period, they were run at the conclusion of the study at 300 days in order to complete the record. The results are presented in Table II following. Coliforms were not run, as they had been essentially zero initially.

TABLE II

BACTERIOLOGICAL EXAMINATION OF TAP WATERS USED

SOURCE OF WATER	COLIFORM BACTERIA PER 100 ml. As Received [1]	TOTAL BACTERIA PER ml. (STANDARD PLATE COUNT, 35° C)		
		INITIAL COUNT	30-DAY COUNT [3]	300-DAY COUNT [4]
ATLANTA	Less than 2	T.F.T.C. [2]	T.F.T.C.	Less than 1
CHICAGO	" " "	8,000	630	" " "
HOUSTON	" " "	24,000	58,000	(300,000 (400,000 (300,000
KANSAS CITY	" " "	T.F.T.C.	350	Less than 1
LOS ANGELES	" " "	130	11,000	" " "
MIAMI	" " "	7,800	T.F.T.C.	" " "
NEW YORK	" " "	7,600	59	" " "
PHOENIX	" " "	T.F.T.C.	4,400	" " "
SEATTLE	" " "	1,600	T.F.T.C.	" " "
WATERTOWN	" " "	810	130,000	" " "

[1] Five portions of 10 ml. each used.
[2] Too few to count
[3] Single samples in duplicate.
[4] Duplicates on samples from all three liner materials.

It may be seen that all viable organisms had decreased to essentially zero at the end of 300 days with the exception of those in the water from Houston.

C O N C L U S I O N S

In general the results of these small volume storage tests confirm those obtained from the storage tests in the large drums. Polyethylene appears to be the only liner material which is suitable for storage of water over extended periods from the standpoint of taste, evaporation loss, and liner integrity.

While discernible differences were observed in the waters obtained from the ten different geographical areas, these differences did not appear to be of sufficient magnitude to warrant any definite conclusions relating source to storage behavior, with two exceptions; as pointed out above, the Chicago water had a low rating on the taste tests, and the Houston water was the only water to show high bacteriological plate counts after 300 days' storage. It is felt that these waters may be unsuited for long term storage.